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**BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES**

Application Number: 10/764,908
Filing Date: January 26, 2004
Appellant(s): LEI, FANG

MAILED
SEP 2 6 2007
GROUP 2800

Wesley W. Whitmyer, Jr.
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed on 7/3/2007 appealing from the Office action mailed 1/24/2007.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

No amendment after final has been filed.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

61-20015	TAKAHASHI	1-1986
5,743,846	TAKAHASHI et al	4-1998

(9) Grounds of Rejection

The following grounds of rejection are applicable to the appealed claims:

I) Claims 1, 3, 8-9, 11-14, 16 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Takahashi (Japanese reference No. 61-20015) in view of Takahashi et al (U.S. Patent No. 5,743,846).

Takahashi in his Japanese reference No. 61-20015, hereafter, Takahashi '015, discloses an image transmission system having a plurality of image transmission units. See page 91, columns 1-2 and fig. 1. Each image transmission unit comprises a center rod lens and two outer rod lens elements wherein the center rod lens element is a combination of a center lens elements and two outer lens elements cemented to the center lens elements on the opposite sides of the center lens element. See pages 92-95 and figs. 3-8.

In the embodiment of the image transmission unit as described in page 93, columns 7-8 and shown in figure 4, the image transmission unit comprises a center rod lens element (7) and two outer rod lens elements (5, 6) disposed on opposite sides of the center rod lens element (7) and in a symmetrical manner to one another with respect to the center lens element. The center rod lens element is a combination of a rod main biconcave lens element and two biconvex lens elements cemented to the main rod biconcave element to form a biconvex center rod lens element, and in combination form a cylinder. It is noted that the center rod biconcave lens element is symmetrical with respect to its center plane perpendicular to the optical axis of the image transmission unit and the lens

surfaces of the main rod biconcave lens element and the two cemented biconvex lens elements are also symmetrical with respect to the center plane perpendicular to the optical axis of the image transmission unit and the center rod biconcave lens element. Each of the outer rod lens elements (5,6) is a biconvex rod lens element and is made as one piece. The center biconvex lens element (7) and the two biconvex outer rod lens elements (5, 6) are arranged in a vertex-to-vertex adjacent configuration to one another without any distancing tubes located between the rod lens elements. Regarding to the material of the lens elements, Takahashi '015 discloses that the material of the lens elements is homogenous material.

Regarding to the shape of the lens surfaces of the lens elements, the optical data as provided in columns 7-8 disclose that the shape of each lens surfaces of the lens elements is spherical shape with the following values:

The outer biconvex rod lens element (5) has its entrance lens surface of value 10.578 and its exit lens surface of value 35.259;

The outer biconvex rod lens element (6) has its entrance lens surface of value 35.259 and its exit lens surface of value 10.578; and

The center biconvex rod lens element (7) has three lens elements wherein the first biconvex lens element facing the outer rod lens element (5) has its entrance lens surface of value 9.441 and its exit lens surface of value 4.612; the biconcave element cemented to the exit lens surface of the first biconvex lens element has its entrance lens surface of value 4.612 and its exit lens surface of value 4.612;

and the second biconvex lens element cemented to the exit lens surface of the biconcave lens element has its entrance lens surface of value 4.612 and its exit lens surface of value 9.441.

As a result of such a structure, the image transmission unit having two outer rod lens elements (5,6) and a center rod lens element (7) provided by Takahashi '015 meets all of the features recited in the claims 1, 3, 8-9, 11-14, 16 and 17, except that he does not disclose that the length of the center rod lens element is essentially same or longer than the length of each of the outer rod lens elements (5,6) as claimed in present claim 1.

However, the use of an image transmission system having a plurality of image transmission units each comprises a center rod lens and two outer rod lens elements wherein the length of the center rod lens element is essentially the same as that of the outer rod lens element is disclosed in the art as can be seen in the endoscope provided by Takahashi et al in their U.S. Patent No. 5,743,846, hereafter, Takahashi et al '846.

In particular, Takahashi et al disclose an endoscope having an image transmission system. The image transmission system comprises a plurality of image transmission units in which each unit comprises a center rod lens element and two outer rod lens elements disposed on the opposite sides of the center rod lens element and in a symmetrical to one another with respect to the center lens element. Regarding to the dimensions of the rod lens elements, Takahashi et al

'846 disclose that the length of the center rod lens element can be shorter than or essentially the same as the length of the outer rod lens element.

As shown in each embodiments described in columns 44-48, Tables 1-5, and shown in figures 6, 8, 11, 12, and 13, the length of the center rod lens element is shorter than the length of each of the outer rod lens elements disposed on opposite sides of the center rod lens element. For instance, in Table 1, the length of the center rod lens is about 12.0 while the length of each outer rod lens element is about 45.743. In Table 4, the length of the center rod lens is about 12.0 while the length of each outer rod lens element is about 44.40.

However, the length of the center lens element is essentially the same as the length of the outer rod lens elements is disclosed by Takahashi et al '846 as shown in each embodiments described in columns 48-52, Tables 6-7 and 9, and shown in figures 20-21 and 24. For instance, in Table 6, columns 48-49, the length of the center rod lens is about 29.469 while the length of each outer rod lens element is about 29.648. In Table 7, columns 49-50, the length of the center rod lens is about 31.679 while the length of each outer rod lens element is about 31.497. In Table 9, columns 51-52, the length of the center rod lens is about 29.683 while the length of each outer rod lens element is about 29.166.

As a result of teachings provided by Takahashi et al '846, i.e., the length of the center rod lens element can be shorter than or essentially the same as the length of the outer rod lens element. Thus, it would have been obvious to one skilled in the art at the time the invention was made to modify the image transmission unit

having a center rod lens element and two outer rod lens elements disposed on opposite sides of the center rod lens element as provided by Takahashi '015 by using a center rod lens element having its length essentially the same as the length of the outer rod lens element as suggested by Takahashi et al '846 for the purpose of enlargement the numerical aperture to allow a greater number of light rays pass through the image transmission unit and thus increase the brightness.

II). Claims 1, 5-9, 11-14, 16 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Takahashi (Japanese reference No. 61-20015) in view of Takahashi et al (U.S. Patent No. 5,743,846).

Takahashi in his Japanese reference No. 61-20015, hereafter, Takahashi '015, discloses an image transmission system having a plurality of image transmission units. See page 91, columns 1-2 and fig. 1. Each image transmission unit comprises a center rod lens and two outer rod lens elements wherein the center rod lens element is a combination of a center lens elements and two outer lens elements cemented to the center lens elements on the opposite sides of the center lens element. See pages 92-95 and figs. 3-8.

In the embodiment of the image transmission unit as described in page 93, column 9 and shown in figure 5, the image transmission unit comprises a center rod lens element (7) and two outer rod lens elements (5, 6) disposed on opposite sides of the center rod lens element (7) and in a symmetrical manner to one another with respect to the center lens element. The center rod lens element is a combination of a rod main biconvex lens element and two meniscus negative

lens elements cemented to the main rod biconcave element to form a biconvex center rod lens element, and in combination form a cylinder. It is noted that the center rod biconvex lens element is symmetrical with respect to its center plane perpendicular to the optical axis of the image transmission unit and the lens surfaces of the main rod biconcave lens element and the two cemented meniscus lens elements are also symmetrical with respect to the center plane perpendicular to the optical axis of the image transmission unit and the center rod biconvex lens element. Each of the outer rod lens elements (5,6) is a biconvex rod lens element and is made as one piece. The center biconvex lens element (7) and the two biconvex outer rod lens elements (5, 6) are arranged in a vertex-to-vertex adjacent configuration to one another without any distancing tubes located between the rod lens elements. Regarding to the material of the lens elements, Takahashi '015 discloses that the material of the lens elements is homogenous material.

Regarding to the shape of the lens surfaces of the lens elements, the optical data as provided in column 9 disclose that the shape of each lens surfaces of the lens elements is spherical shape with the following values:

The outer biconvex rod lens element (5) has its entrance lens surface of value 13.715 and its exit lens surface of value 13.715;

The outer biconvex rod lens element (6) has its entrance lens surface of value 13.715 and its exit lens surface of value 13.715; and

The center biconvex rod lens element (7) has three lens elements wherein the first meniscus negative lens element facing the outer rod lens element (5), has its entrance lens surface of value 12.338 and its exit lens surface of value 7.471; the biconvex element cemented to the exit lens surface of the first meniscus lens element has its entrance lens surface of value 7.471 and its exit lens surface of value 7.471; and the second meniscus negative lens element cemented to the exit lens surface of the biconvex lens element has its entrance lens surface of value 7.471 and its exit lens surface of value 12.338.

As a result of such a structure, the image transmission unit having two outer rod lens elements (5,6) and a center rod lens element (7) provided by Takahashi '015 meets all of the features recited in the claims 1, 5-9, 11-14, 16 and 17, except that he does not disclose that the length of the center rod lens element is essentially same or longer than the length of each of the outer rod lens elements (5,6) as claimed in present claim 1, and the meniscus lens element cemented to the biconvex lens element of the center rod lens has a positive power as claimed in present claim 6.

Regarding to the power of the meniscus lens elements cemented to the biconvex lens element of the center rod lens element as recited in present claim 6, such a feature is not critical to the invention as stated in the specification and in the present claims. The support for this conclusion is found in the specification in which applicant has disclosed that the meniscus lens element has a negative power. It is also noted that the negative power of the meniscus lens is indeed

claimed as can be seen in the present claim 7. Thus, absent any showing of criticality, it would have been obvious to one skilled at the time the invention was made to use any meniscus lens element of negative or positive power with the biconvex lens for the purpose of adjusting the power of the whole lens element. Regarding to the feature related to the comparison between the lengths of the center rod lens element and the outer rod lens element, it is noted that the use of an image transmission system having a plurality of image transmission units each comprises a center rod lens and two outer rod lens elements wherein the length of the center rod lens element is essentially the same as that of the outer rod lens element is disclosed in the art as can be seen in the endoscope provided by Takahashi et al in their U.S. Patent No. 5,743,846, hereafter, Takahashi et al ‘846.

In particular, Takahashi et al disclose an endoscope having an image transmission system. The image transmission system comprises a plurality of image transmission units in which each unit comprises a center rod lens element and two outer rod lens elements disposed on the opposite sides of the center rod lens element and in a symmetrical to one another with respect to the center lens element. Regarding to the dimensions of the rod lens elements, Takahashi et al ‘846 disclose that the length of the center rod lens element can be shorter than or essentially the same as the length of the outer rod lens element.

As shown in each embodiments described in columns 44-48, Tables 1-5, and shown in figures 6, 8, 11, 12, and 13, the length of the center rod lens element is

shorter than the length of each of the outer rod lens elements disposed on opposite sides of the center rod lens element. For instance, in Table 1, the length of the center rod lens is about 12.0 while the length of each outer rod lens element is about 45.743. In Table 4, the length of the center rod lens is about 12.0 while the length of each outer rod lens element is about 44.40.

However, the length of the center lens element is essentially the same as the length of the outer rod lens elements is disclosed by Takahashi et al '846 as shown in each embodiments described in columns 48-52, Tables 6-7 and 9, and shown in figures 20-21 and 24. For instance, in Table 6, columns 48-49, the length of the center rod lens is about 29.469 while the length of each outer rod lens element is about 29.648. In Table 7, columns 49-50, the length of the center rod lens is about 31.679 while the length of each outer rod lens element is about 31.497. In Table 9, columns 51-52, the length of the center rod lens is about 29.683 while the length of each outer rod lens element is about 29.166.

As a result of teachings provided by Takahashi et al '846, i.e., the length of the center rod lens element can be shorter than or essentially the same as the length of the outer rod lens element. Thus, it would have been obvious to one skilled in the art at the time the invention was made to modify the image transmission unit having a center rod lens element and two outer rod lens elements disposed on opposite sides of the center rod lens element as provided by Takahashi '015 by using a center rod lens element having its length essentially the same as the length of the outer rod lens element as suggested by Takahashi et al '846 for the

purpose of enlargement the numerical aperture to allow a greater number of light rays pass through the image transmission unit and thus increase the brightness.

(10) Response to Argument

Appellant's arguments provided on the Appeal Brief of 7/3/2007, pages 3-10, with respect to the rejections of claims 1, 3, 5-9, 11-14, 16 and 17 have been fully considered but they are not persuasive for the following reasons.

A) Regarding to the appellant's arguments that there is no suggestion to combine the references, the examiner recognizes that obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. See *KSR Int'l Co. v. Teleflex, Inc.* 127 S. Ct. 1727, 1740, 82 USPQ2d 1385, 1396 (Fed. Cir. 2007); *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988) and *In re Jones*, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992). In this case, both references used in the rejections of the claims are directed to optical device having a plurality of image transmission units wherein each image transmission unit comprises a center rod lens and two outer rod lens elements wherein the center rod lens element is a combination of a center lens elements and two outer lens elements cemented to the center lens elements on the opposite sides of the center lens element. As such, both references used in the rejections of the claims are clearly from a common field of endeavour. The primary reference, the Japanese reference No. 61-20015 issued to Takahashi, hereafter, Takahashi '015, discloses an image transmission system having a

plurality of image transmission units wherein each image transmission unit comprises a center rod lens and two outer rod lens elements wherein the center rod lens element is a combination of a center lens elements and two outer lens elements cemented to the center lens elements on the opposite sides of the center lens element. See pages 92-95 and figs. 3-8. The endoscope provided by Takahashi et al in their U.S. Patent No. 5,743,846, hereafter, Takahashi et al '846, which is used as a secondary reference discloses/suggests to one skilled in the art a fact that the length of the center rod lens element can be shorter than or essentially the same as the length of the outer rod lens element. To support for that suggestion, Takahashi et al '846 indeed disclose a numerous examples in which some examples show that the length of the center lens is shorter than the length of the outer lens and some examples show that the length of the center lens is essentially the same as the length of the outer lens. As a result, it would have been obvious to one skilled in the art at the time the invention was made to modify the lens system having plural image transmission units provided by Takahashi '015 by making the length of the center lens essentially the same as that of the outer lens as suggested by Takahashi et al '846 to meet a particular design or a particular application. See *KSR Int'l Co. v. Teleflex, Inc.* 127 S. Ct. 1727, 1740, 82 USPQ2d 1385, 1396 (Fed. Cir. 2007).

B) Regarding to the appellant's arguments that the arrangement of lens elements as provided by Takahashi in his Japanese reference No. 61-20015, hereafter, Takahashi '015 does not disclose that the lens elements are arranged to a vertex-to-

vertex manner as claimed. The examiner respectfully disagrees with the appellant's opinions for the following reasons.

First, appellant's arguments fail to comply with 37 CFR 1.111(b) because they amount to a general allegation that the claims define a patentable invention without specifically pointing out how the language of the claims patentably distinguishes them from the references;

Second, it is noted that the claims have not provided any limitations/features to clarify the so-called "vertex-to-vertex" arrangement of the lens elements. Appellant should note that a vertex-to-vertex arrangement of the lens elements does not mean that the vertex of the lens elements is in contact with each other. In response to appellant's argument that the references fail to show certain features of appellant's invention, it is noted that the features upon which appellant relies (i.e., the vertex at one end of a rod lens abuts the vertex of an end of the rod lens next to it) are not recited in the rejected claims. Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993).

Third, the lens arrangement of the lens elements as provided by Takahashi '015 as provided in page 93, columns 7-8 and shown in fig. 4 is a vertex-to-vertex arrangement because the vertex of the outer lens element (5) on its image side faces to the vertex of the central lens (7) on its entrance side and the vertex of the central lens (7) on its image side faces the vertex of the outer lens (6) on its entrance side.

(11) Related Proceeding(s) Appendix

No decision rendered by a court or the Board is identified by the examiner in the Related Appeals and Interferences section of this examiner's answer.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

Thong Nguyen

Conferees:

Ricky Mack -- SPE Art Unit 2873

Stephone B. Allen -- SPE Art Unit 2872

Thong Nguyen -- PE Art Unit 2872

PTO 07-2124

Japanese Kokai Patent Application
No. Sho 610[1986]-20015

IMAGE TRANSFER OPTICAL SYSTEM

Susumu Takahashi

UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. FEBRUARY 2007
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IMAGE TRANSFER OPTICAL SYSTEM

[Zotendatsu kogakukei]

Inventor:	Susumu Takahashi
Applicant:	Olympus Optical Co. Ltd.

[There are no amendments to this patent.]

Claims /1*

1. A type of image transfer optical system characterized by the fact that it has a first cylindrical lens with convex surface on the incident side, a second cylindrical lens with convex surface on the exit side, and a biconvex lens having at least two negative bonding surfaces set between said first cylindrical lens and said second cylindrical lens.

2. The image transfer optical system described in Claim 1 characterized by the fact that the two lenses that sandwich the bonding surface between them have a difference in refractive index larger than 0.04.

* [Numbers in right margin indicate pagination of the original text.]

Detailed explanation of the invention

Technical field

The present invention pertains to a type of image transfer optical system for use in a hard endoscope or the like.

Prior art

As shown in Figure 1, for a hard endoscope, inside fine-diameter outer tube (1), the following lenses are set in tandem from the object side: objective lens (2), image transfer optical systems (3), (3'), ..., and eyepiece (4). Object image Q formed by objective lens (2) is sequentially relayed as Q', Q", ... by said image transfer optical systems (3), (3'), ..., respectively, and final image Q_L is observed via said eyepiece (4). For example, a well-known image transfer optical system of this type is described in Japanese Kokoku Patent Application No. Sho 49[1974]-5993. As shown in Figure 2, this image transfer optical system has two cylindrical positive lenses, each prepared by bonding a positive lens and a negative lens to each other, set with their negative lenses facing each other. Consequently, it is possible to perform good correction for the spherical aberration, comma aberration, and chromatic aberration. However, the correction for the field curvature is insufficient, and astigmatism is also present. As a result, when there are many rounds of relay of the image, the field curvature and astigmatism accumulate up to a very high level. As a result, it is impossible to focus the center and periphery of the field of view at the same time, and this is undesirable.

Purpose of the invention

The present invention provides a type of image transfer optical system that can make good correction for the field curvature.

Summary of the present invention /2

The aforementioned purpose is realized by a type of image transfer optical system characterized by the fact that it has a first cylindrical lens with convex surface on the incident side, a second cylindrical lens with convex surface on the exit side, and a biconvex lens having at least two negative bonding surfaces set between said first cylindrical lens and said second cylindrical lens. That is, in this constitution, the convex surface on the incident side of the first cylindrical lens and the convex surface on the exit side of the second cylindrical lens each act as a view field lens, and the exit side surface of the first cylindrical lens and the incident side surface of the second cylindrical lens, as well as the biconvex lens sandwiched between them, play the role of an imaging lens. As a result, due to the negative function of the at least two

bonding surfaces formed on the two cylindrical lenses, the field curvature can be corrected effectively.

Application examples

<u>Application Example 1</u>

Figure 3 is a diagram illustrating Application Example 1 of the present invention. In this application example, the image transfer optical system is composed of cylindrical planar-convex lens (5) having a convex surface on the incident side, cylindrical planar-convex lens (6) having convex surface on the exit side, and positive-negative-positive biconvex bonded lens (7) sandwiched between them. The lens data are as follows.

$r_1 = 9.601$			
	$d_1 = 22.21$	$n_1 = 1.51633$	$\nu_1 = 64.15$
$r_2 = \infty$			
	$d_2 = 1.89$		
$r_3 = 8.258$			
	$d_3 = 1.19$	$n_2 = 1.65160$	$\nu_2 = 58.67$
$r_4 = -4.032$			
	$d_4 = 3.70$	$n_3 = 1.7570$	$\nu_3 = 47.87$
$r_5 = 4.032$			
	$d_5 = 1.19$	$n_4 = 1.65160$	$\nu_4 = 58.67$
$r_6 = -8.258$			
	$d_6 = 1.89$		
$r_7 = \infty$			
	$d_7 = 22.21$	$n_5 = 1.51633$	$\nu_5 = 64.15$
$r_8 = -9.601$			

Here, r_i represents the radius of curvature of the i^{th} surface; d_i represents the portion between the i^{th} surface and the (i+1) surface; nj, vj represent the refractive index and Abbe number of the j^{th} lens, respectively.

Because the bonding surface has a negative function, naturally, one has $n_2, n_4 < n_3$, especially, for correction of the various aberrations, it is preferred that

$$n_3 - n_2,\ n_3 - n_4 > 0.04$$

That is, if this difference in refractive index is smaller than 0.04, the negative function of the bonding surface is too small, so that correction of the field curvature is insufficient. In order

to increase the negative function, the curvature of the bonding surface should be very large, leading to increase in the curvature of the spherical aberration and comma aberration.

On the other hand, in order to make sufficient good correction for the chromatic aberration, it is preferred that $\nu_2 - \nu_3,\ \nu_4 - \nu_3 > 4$. If the Abbe number difference is smaller than 4, the correcting power for the chromatic aberration becomes weak, and the overall chromatic aberration tends to be corrected insufficiently.

Also, for this optical system, the entirety is completely symmetrical with respect to the optical axis passing through the center of the biconvex lens. This is effective in suppressing generation of asymmetric aberration of the overall system.

Application Example 2

The lens configuration is the same as that in Application Example 1. The lens data are as follows.

$r_1 = 7.202$

$d_1 = 16.88 \quad n_1 = 1.51633 \quad \nu_1 = 64.15$

$r_2 = \infty$

$d_2 = 1.50$

$r_3 = 5.955$

$d_3 = 0.88 \quad n_2 = 1.62004 \quad \nu_2 = 36.25$

$r_4 = -2.008$

$d_4 = 2.19 \quad n_3 = 1.72151 \quad \nu_3 = 36.26$

$r_5 = 2.908$

$d_5 = 0.88 \quad n_4 = 1.62004 \quad \nu_4 = 36.25$

$r_6 = -5.955$

$d_6 = 1.50$

$r_7 = \infty$

$d_7 = 16.88 \quad n_5 = 1.51633 \quad \nu_5 = 64.15$

$r_8 = -7.202$

Application Example 3

The lens configuration is the same as that in Application Example 1. The lens data are as follows. /3

$r_1 = 7.202$

$d_1 = 16.88 \quad n_1 = 1.51633 \quad \nu_1 = 64.15$

$r_2 = \infty$

$d_2 = 1.50$

$r_3 = 5.141$

$d_3 = 0.88 \quad n_2 = 1.62299 \quad \nu_2 = 58.14$

$r_4 = -3.127$

$d_4 = 2.19 \quad n_3 = 1.7880 \quad \nu_3 = 47.43$

$r_5 = 3.127$

$d_5 = 0.88 \quad n_4 = 1.62299 \quad \nu_4 = 58.14$

$r_6 = -5.141$

$d_6 = 1.50$

$r_7 = \infty$

$d_7 = 16.88 \quad n_5 = 1.51633 \quad \nu_5 = 64.15$

$r_8 = -7.202$

<u>Application Example 4</u>

Figure 4 is a diagram illustrating Application Example 4 of the present invention. In this case, both the exit side surface of the first cylindrical lens and the incident side surface of the second cylindrical lens are convex surfaces. The lens data are as follows.

$r_1 = 10.578$			
	$d_1 = 18.84$	$n_1 = 1.51633$	$\nu_1 = 64.15$
$r_2 = -35.259$			
	$d_2 = 4.27$		
$r_3 = 9.441$			
	$d_3 = 3.29$	$n_2 = 1.6400$	$\nu_2 = 60.09$
$r_4 = -4.612$			
	$d_4 = 1.50$	$n_3 = 1.7570$	$\nu_3 = 47.87$
$r_5 = 4.612$			
	$d_5 = 3.29$	$n_4 = 1.6400$	$\nu_4 = 60.09$
$r_6 = -9.441$			
	$d_6 = 4.27$		
$r_7 = 35.259$			
	$d_7 = 18.84$	$n_5 = 1.51633$	$\nu_5 = 64.15$
$r_8 = -10.578$			

In this example, the positive refractive power of the exit side surface of the first cylindrical lens and the incident side surface of the second cylindrical lens pick up a portion of the function of the imaging lens. As a result, the burden on the biconvex lens is reduced. Consequently, it is possible to correct the spherical aberration even better.

Application Example 5

The lens configuration is the same as that in Application Example 4. The lens data are as follows.

$r_1 = 13.715$			
	$d_1 = 17.87$	$n_1 = 1.62004$	$\nu_1 = 36.25$
$r_2 = -13.715$			
	$d_2 = 4.64$		
$r_3 = 12.338$			
	$d_3 = 3.20$	$n_2 = 1.62004$	$\nu_2 = 36.25$
$r_4 = -7.471$			
	$d_4 = 1.50$	$n_3 = 1.80518$	$\nu_3 = 25.43$
$r_5 = 7.471$			
	$d_5 = 3.20$	$n_4 = 1.62004$	$\nu_4 = 36.25$
$r_6 = -12.338$			
	$d_6 = 4.64$		
$r_7 = 13.715$			
	$d_7 = 17.87$	$n_5 = 1.62004$	$\nu_5 = 36.25$
$r_8 = -13.715$			

<u>Application Example 6</u>

Figure 5 is a diagram illustrating Application Example 6. In this case, the biconvex lens sandwiched between the two cylindrical lenses is formed as a negative-positive-negative bonded lens.

The lens data are as follows:

$r_1 = 10.910$

$d_1 = 23.342 \quad n_1 = 1.51633 \quad \nu_1 = 64.15$

$r_2 = \infty$

$d_2 = 1.503$

$r_3 = 8.3923$

$d_3 = 1.151 \quad n_2 = 1.56013 \quad \nu_2 = 46.99$

$r_4 = 3.008$

$d_4 = 8.006 \quad n_3 = 1.51633 \quad \nu_3 = 64.15$

$r_5 = -3.008$

$d_5 = 1.151 \quad n_4 = 1.56013 \quad \nu_4 = 46.99$

$r_6 = -8.3923$

$d_6 = 1.503$

$r_7 = \infty$

$d_7 = 23.342 \quad n_5 = 1.51633 \quad \nu_5 = 64.15$

$r_8 = -10.910$

Application Example 7 /4

Figure 6 is a diagram illustrating Application Example 7 of the present invention. The lens data are as follows.

$r_1 = 12.1848$			
	$d_1 = 25.35$	$n_1 = 1.62004$	$\nu_1 = 36.26$
$r_2 = -23.3626$			
	$d_2 = 1.5$		
$r_3 = 13.9098$			
	$d_3 = 0.8$	$n_2 = 1.62004$	$\nu_2 = 36.25$
$r_4 = 6.2680$			
	$d_4 = 4.5$	$n_3 = 1.51633$	$\nu_3 = 64.15$
$r_5 = -6.2680$			
	$d_5 = 0.8$	$n_4 = 1.62004$	$\nu_4 = 36.25$
$r_6 = -13.9098$			
	$d_6 = 1.5$		
$r_7 = 23.3626$			
	$d_7 = 25.35$	$n_5 = 1.62004$	$\nu_5 = 36.25$
$r_8 = -12.1848$			

<u>Application Example 8</u>

The lens configuration is the same as that in Application Example 7. The lens data are as follows:

$r_1 = 11.5636$			
	$d_1 = 24.953$	$n_1 = 1.62004$	$\nu_1 = 36.25$
$r_2 = -46.5512$			
	$d_2 = 1.103$		
$r_3 = 9.7299$			
	$d_3 = 0.8$	$n_2 = 1.60341$	$\nu_2 = 38.01$
$r_4 = 4.2627$			
	$d_4 = 4.0$	$n_3 = 1.51454$	$\nu_3 = 54.69$
$r_5 = -4.2627$			
	$d_5 = 0.8$	$n_4 = 1.60341$	$\nu_4 = 38.01$
$r_6 = -9.7299$			
	$d_6 = 1.103$		
$r_7 = 46.5512$			
	$d_7 = 24.953$	$n_5 = 1.62004$	$\nu_5 = 36.25$
$r_8 = 11.5636$			

<u>Application Example 9</u>

Figure 7 is a diagram illustrating Application Example 9 of the present invention. In this example, in the biconvex lens, the positive lens is a spherical lens, so that manufacturing becomes easier, and this is an advantage. The lens data are as follows.

$r_1 = 12.045$

$d_1 = 25.35 \quad n_1 = 1.62004 \quad \nu_1 = 36.25$

$r_2 = \infty$

$d_2 = 1.5$

$r_3 = 8.078$

$d_3 = 1.11 \quad n_2 = 1.788 \quad \nu_2 = 47.43$

$r_4 = 4.200$

$d_4 = 4.2 \quad n_3 = 1.58913 \quad \nu_3 = 60.97$

$r_5 = -4.200$

$d_5 = 1.11 \quad n_4 = 1.788 \quad \nu_4 = 47.43$

$r_6 = -8.078$

$d_6 = 1.5$

$r_7 = \infty$

$d_7 = 25.35 \quad n_5 = 1.62004 \quad \nu_5 = 36.25$

$r_8 = -12.045$

Application Example 10

The lens configuration is the same as that in Application Example 9. The lens data are as follows:

$r_1 = 12.022$

$d_1 = 25.35 \quad n_1 = 1.62004 \quad \nu_1 = 36.25$

$r_2 = \infty$

$d_2 = 1.5$

$r_3 = 8.78$

$d_3 = 1.11 \quad n_2 = 1.78472 \quad \nu_2 = 25.71$

$r_4 = 4.258$

$d_4 = 2.129 \quad n_3 = 1.62004 \quad \nu_3 = 36.25$

$r_5 = -4.258$

$d_5 = 1.11 \quad n_4 = 1.78472 \quad \nu_4 = 25.71$

$r_6 = -8.78$

$d_6 = 1.5$

$r_7 = \infty$

$d_7 = 25.35 \quad n_5 = 1.62004 \quad \nu_5 = 36.25$

$r_8 = -12.022$

Application Example 11

Figure 8 is a diagram illustrating Application Example 11 of the present invention. The lens data are as follows:

$r_1 = 10.968$

$d_1 = 23.341 \quad n_1 = 1.51633 \quad \nu_1 = 64.15$

$r_2 = -51.374$

$d_2 = 1.503$

$r_3 = 9.989$

$d_3 = 1.151 \quad n_2 = 1.56013 \quad \nu_2 = 46.99$

$r_4 = 3.505$

$d_4 = 8.006 \quad n_3 = 1.51633 \quad \nu_3 = 64.15$

$r_5 = -3.505$

$d_5 = 1.151 \quad n_4 = 1.56013 \quad \nu_4 = 46.99$

$r_6 = -9.989$

$d_6 = 1.503$

$r_7 = 51.374$

$d_7 = 23.341 \quad n_5 = 1.51633 \quad \nu_5 = 64.15$

$r_8 = -10.963$

Application Example 12

The lens configuration is the same as that in Application Example 11. The lens data are as follows:

$r_1 = 11.613$

$d_1 = 24.577$ $n_1 = 1.62004$ $\nu_1 = 36.25$

$r_2 = -24.115$

$d_2 = 0.7269$

$r_3 = 12.9263$

$d_3 = 0.7962$ $n_2 = 1.60342$ $\nu_2 = 38.01$

$r_4 = 5.5148$

$d_4 = 5.55148$ $n_3 = 1.51633$ $\nu_3 = 64.15$

$r_5 = -5.5148$

$d_5 = 0.7962$ $n_4 = 1.60342$ $\nu_4 = 38.01$

$r_6 = -12.9263$

$d_6 = 0.7269$

$r_7 = 24.115$

$d_7 = 24.577$ $n_5 = 1.62004$ $\nu_5 = 36.25$

$r_8 = -11.613$

Figures 9-20 are diagrams illustrating the aberration curves in said Application Examples 1-12. Figure 21 is a diagram illustrating the aberration curves of the conventional image transfer optical system disclosed in Japanese Kokoku Patent Application No. Sho 49[1974]-5993. In these figures, MS represents the spherical aberration, AS represents the astigmatism, and XX represents the comma aberration.

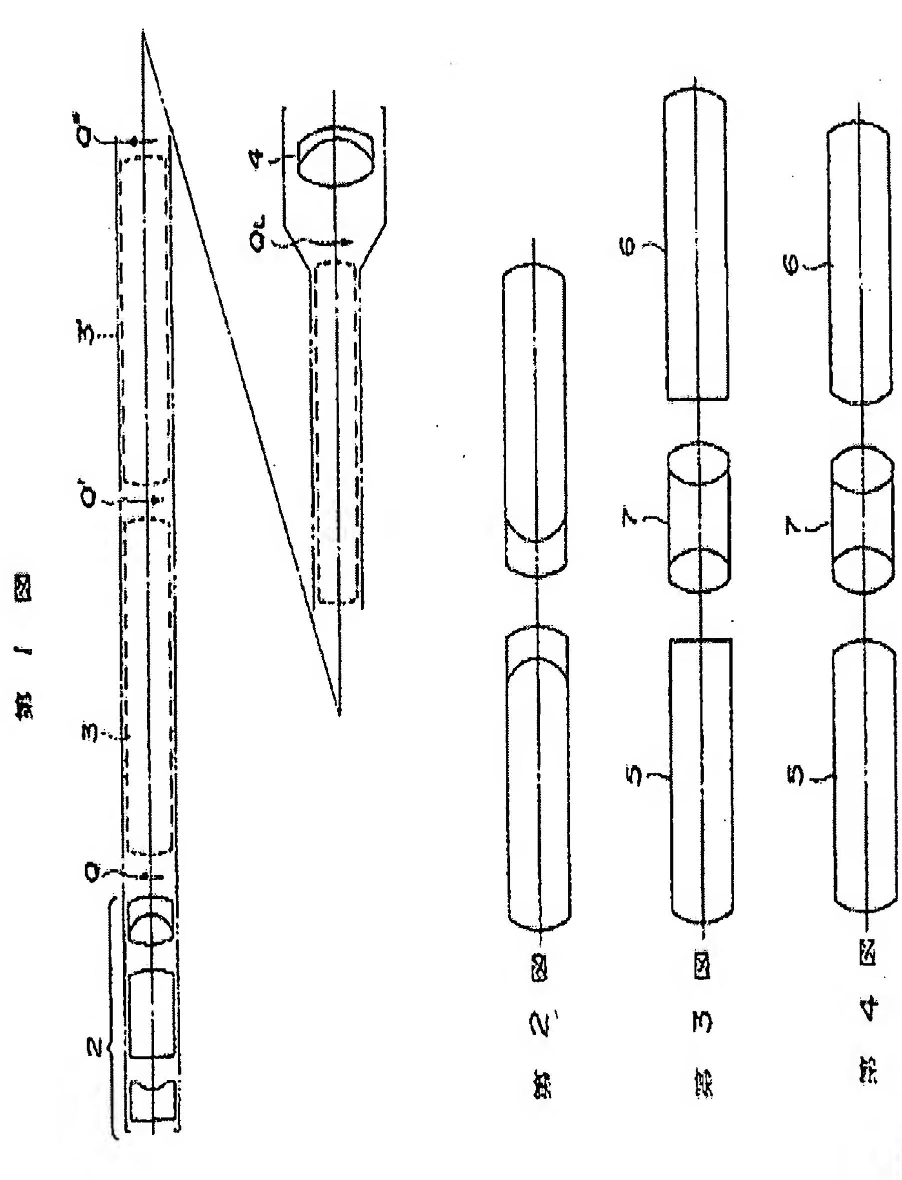
Effects of the present invention

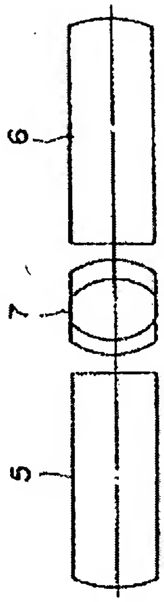
As can be seen from a comparison of the aberration diagrams, the present invention can provide a type of image transfer optical system that can reduce all of the field curvature and astigmatism to lower than half those obtained in the prior art. Consequently, for the hard endoscope using said image transfer optical system, it is free of the problem that focusing cannot be realized simultaneously for both the center and periphery. Also, even when plurality of the image transfer optical systems are set in tandem in use, the accumulated aberration is still not so significant. As a result, it is possible to obtain a long hard endoscope without degradation in the imaging performance.

Brief description of the figures

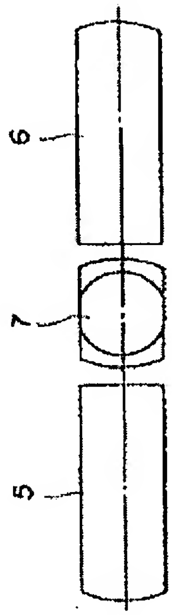
Figure 1 is a diagram illustrating the constitution of the optical system of a hard endoscope of the prior art. Figure 2 is a diagram illustrating the lens configuration of the image transfer optical system in the prior art. Figures 3-8 are diagrams illustrating the lens

configuration in an application example of the present invention. Figures 9-20 are diagrams illustrating the aberration curves in application examples of the present invention. Figure 21 is a diagram illustrating the aberration curves of the image transfer optical system in the prior art.

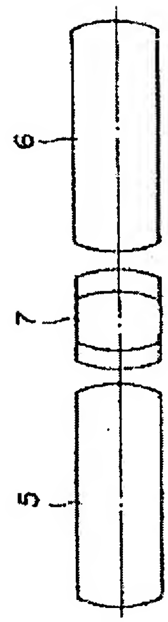




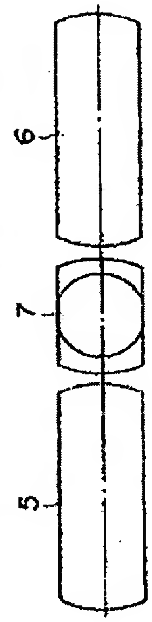
第5図



第7図

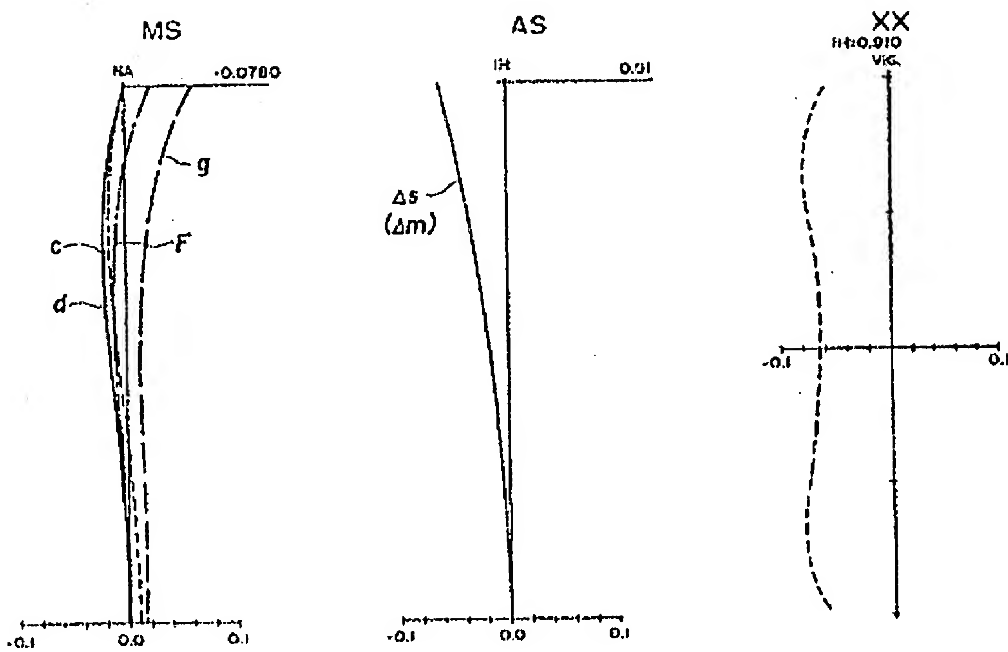


第6図

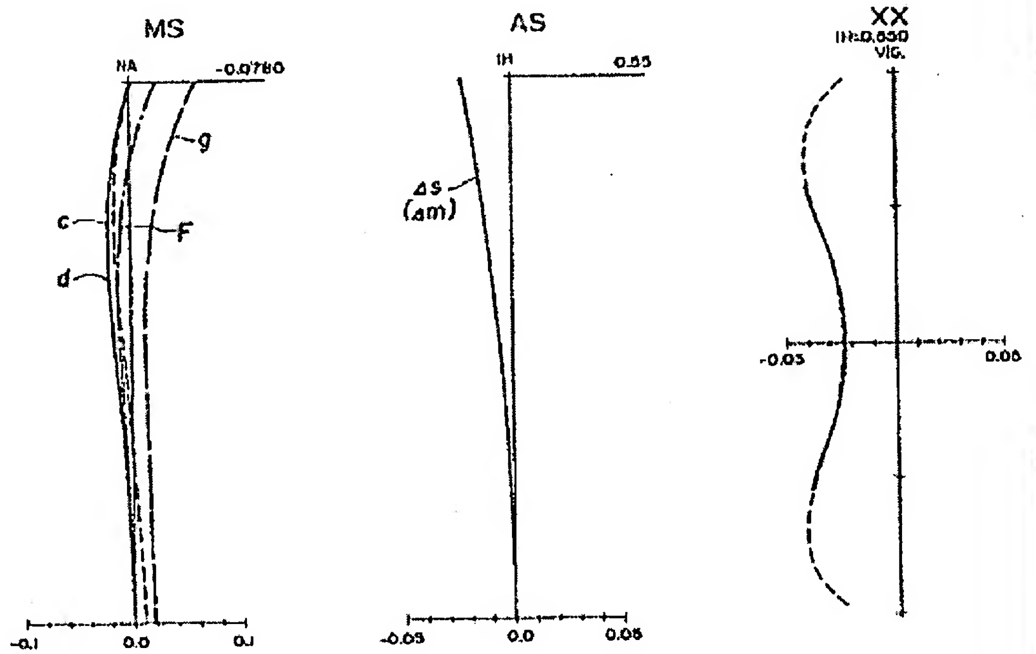


第8図

第 9 図



第 10 図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g
c
F
d
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0.0
0.1
AS
IH
0.55
Δs
(Δm)
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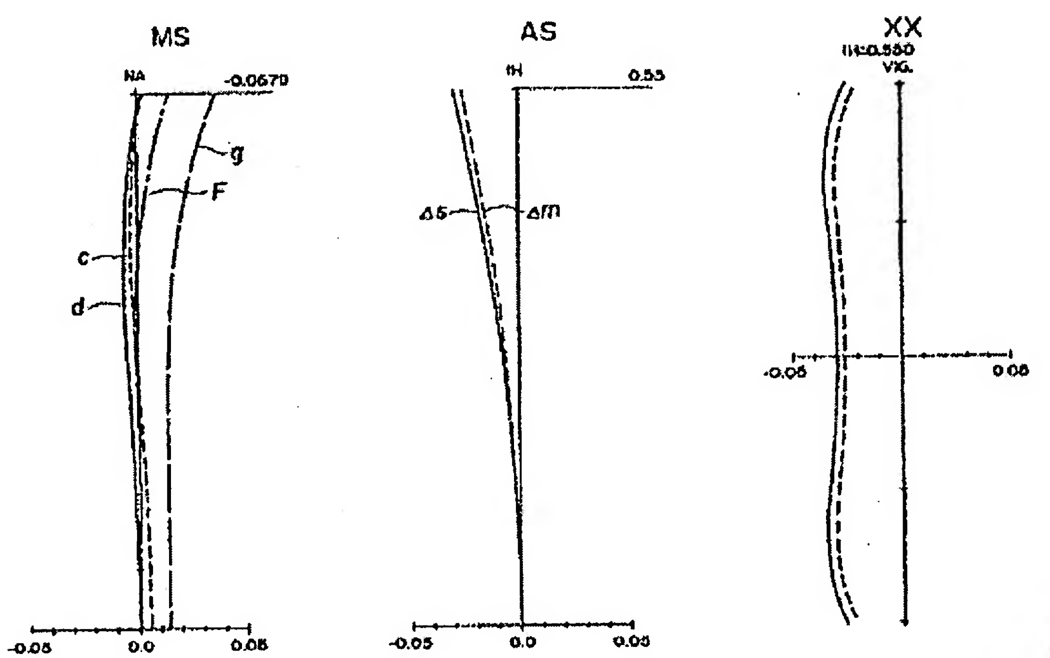
0.0
0.05
XX
IH=0.550
VIG.
-0.05
0.05

第 11 図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VIG.
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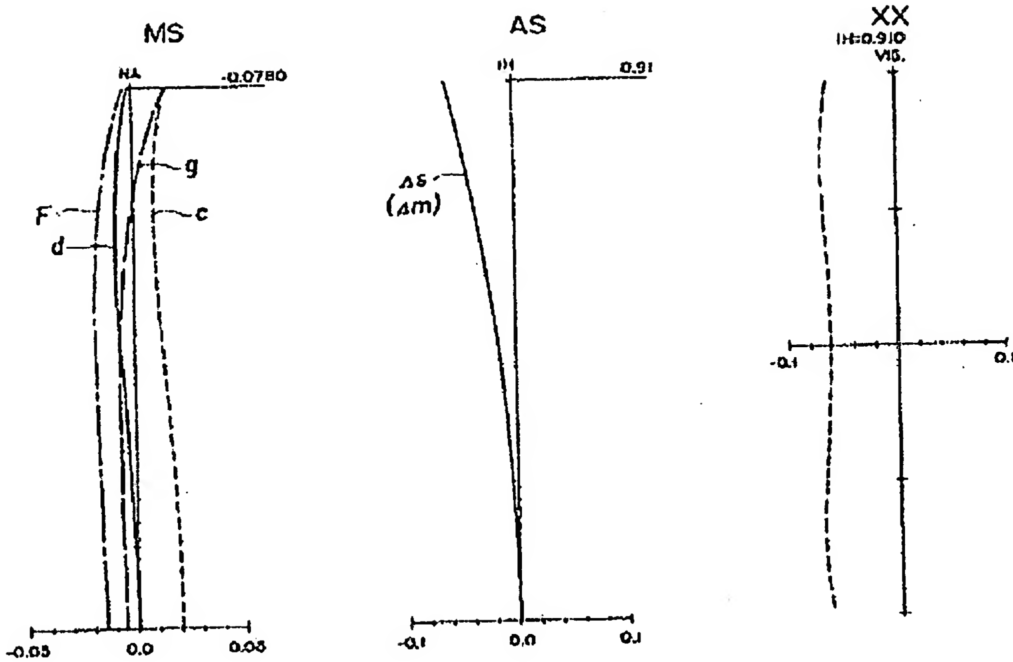
0.05

第 12 図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IH
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ΔS
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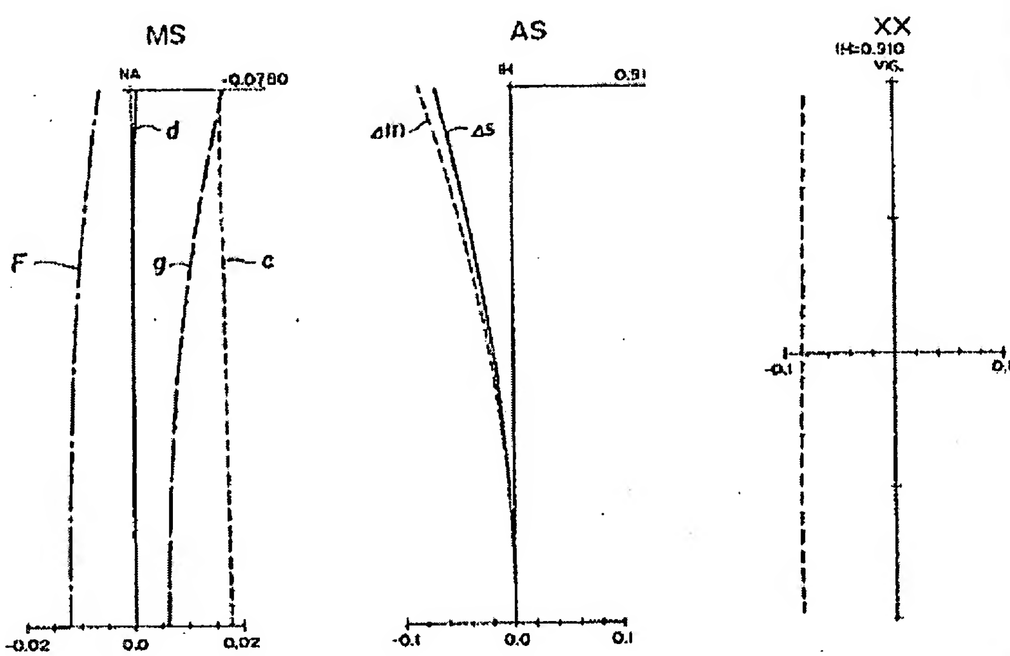
0.0
0.1
XX
IH=0.910
VIG.
-0.1
0.1

第 13 図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XX
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VIG.
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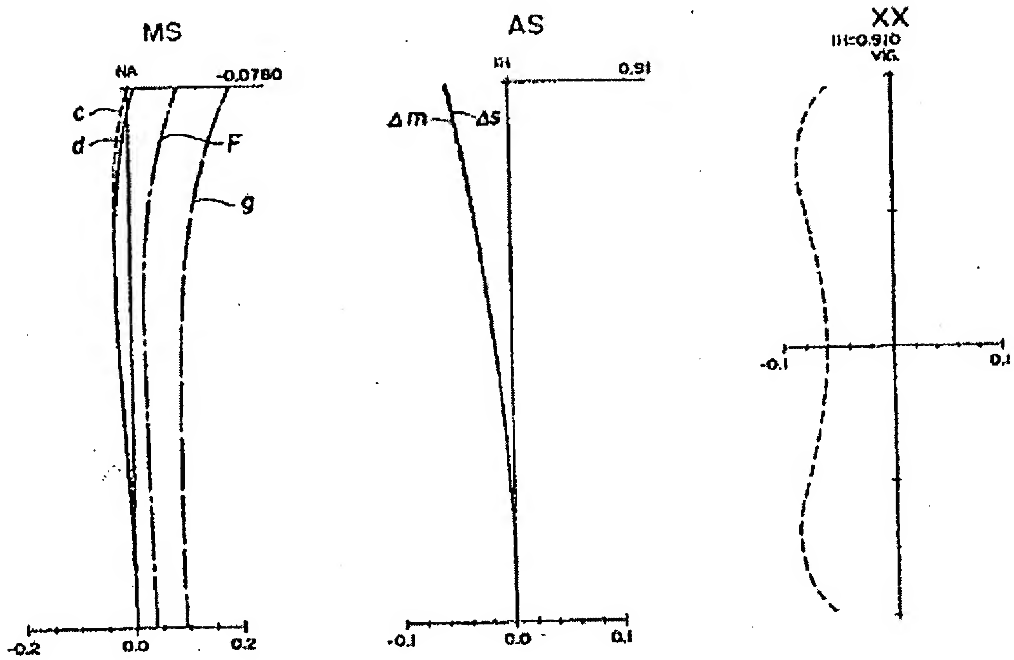
0.1

第 14 図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IH
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Δm
ΔS
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0.0
0.1
XX
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VIG.
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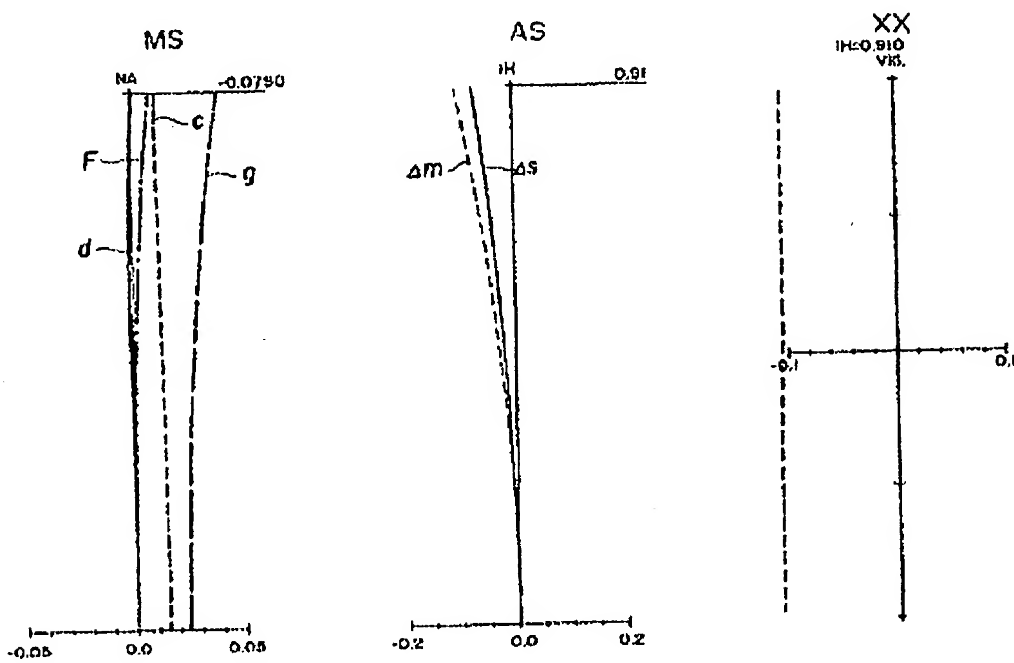
0.1

第 15 図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Δm
ΔS
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0.0
0.2
XX
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VIG.
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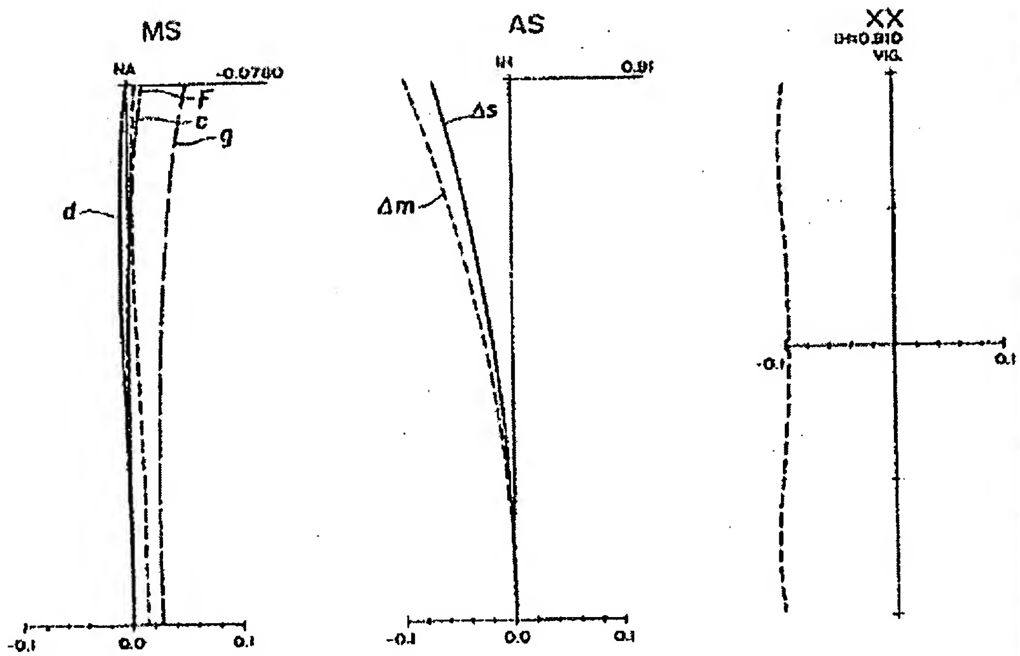
0.1

第 16 図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XX
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VIG.
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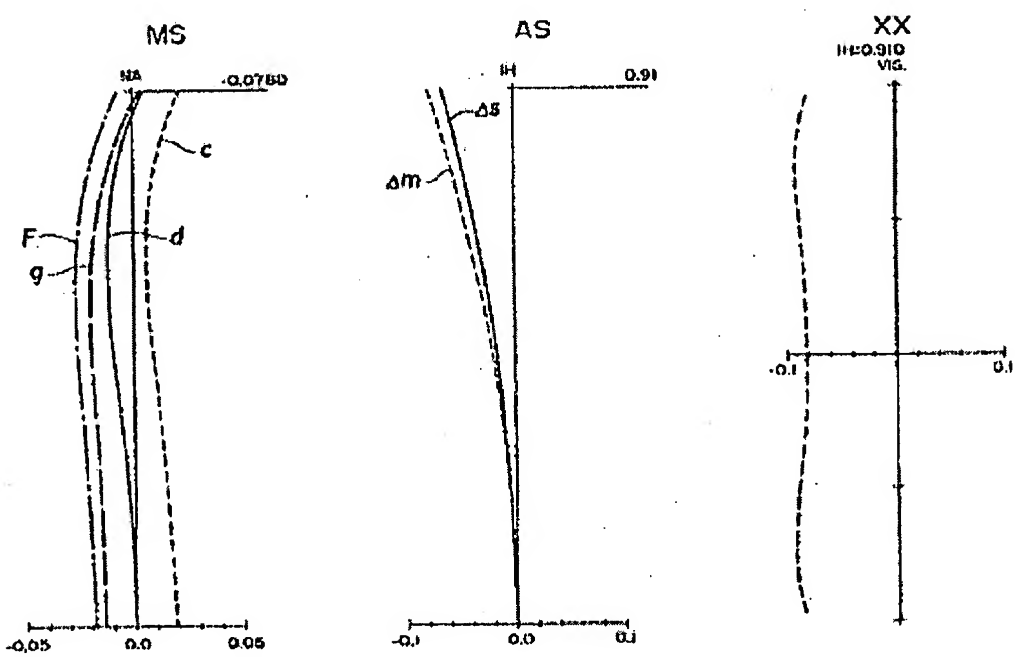
0.1

第 17 図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VIG.
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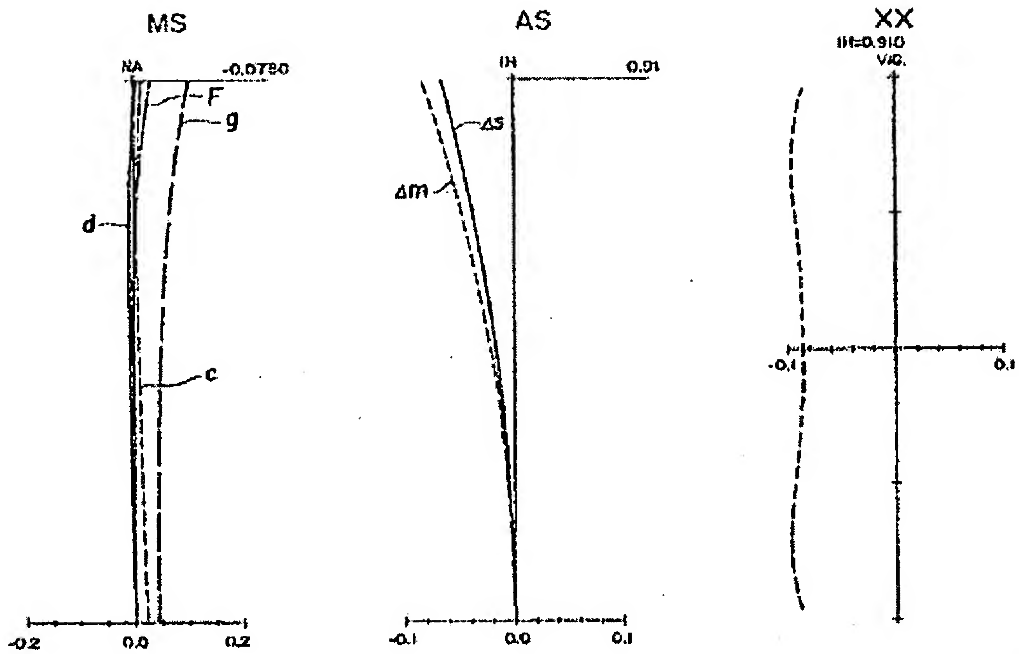
第 18 図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XX
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VIG.
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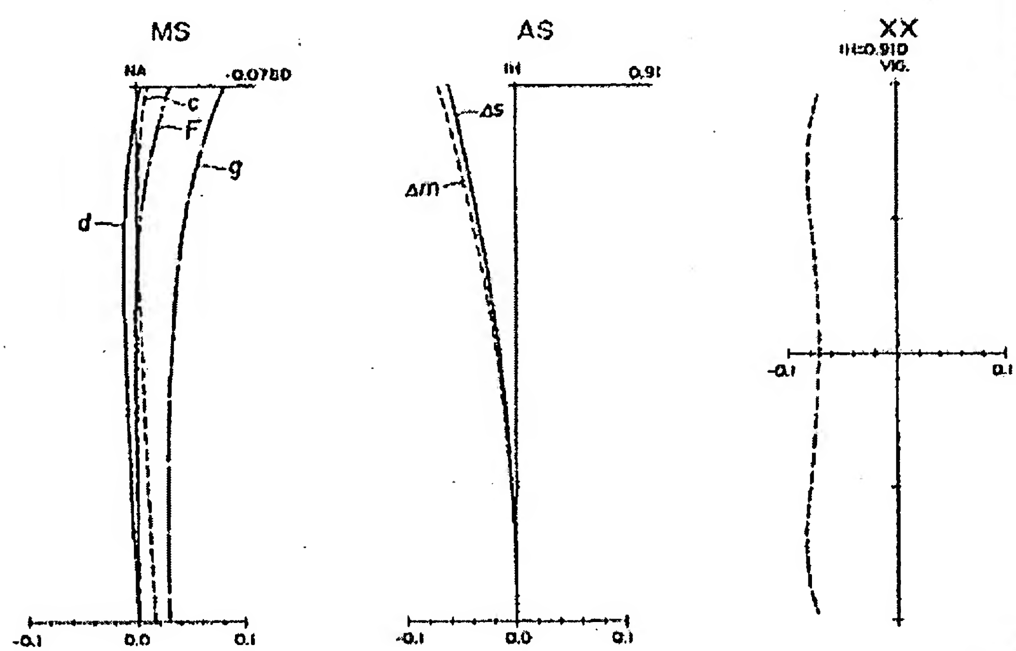
第 19 図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XX
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VIG.
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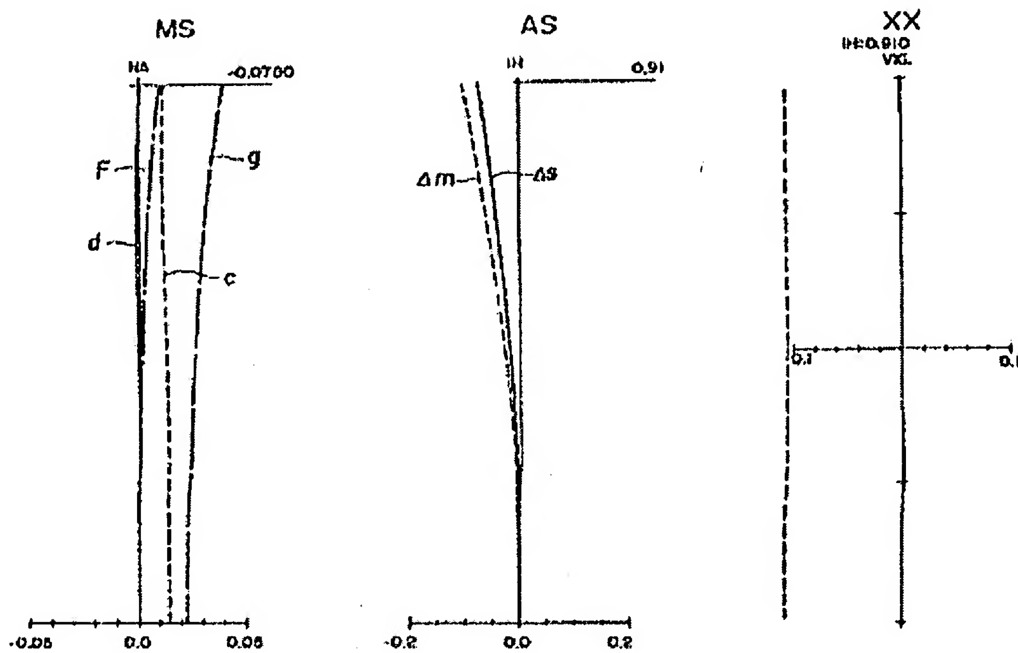
第 20 図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Δs
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XX
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VIG.
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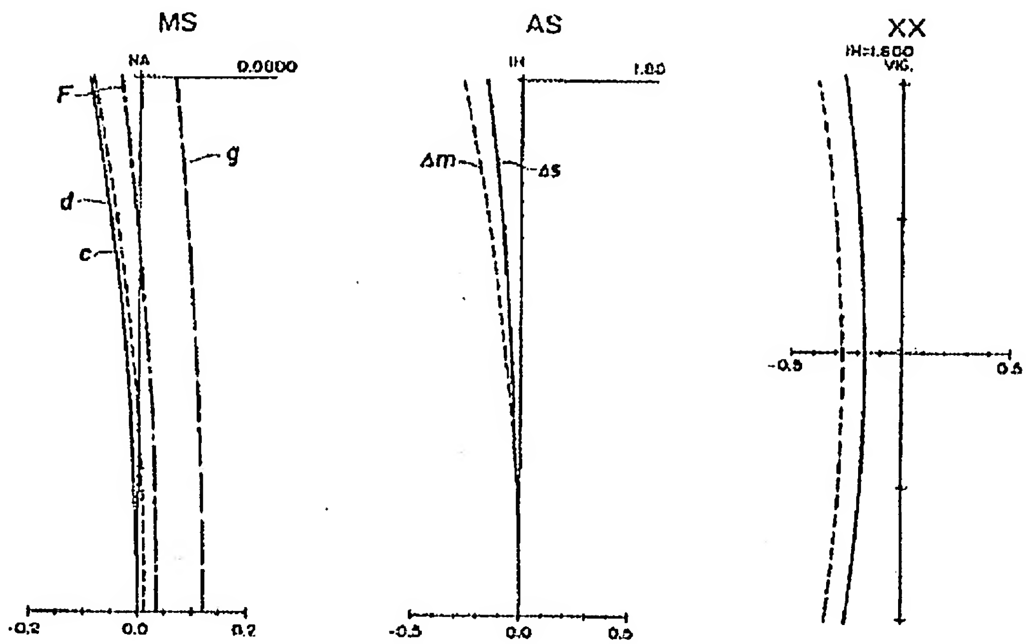
第 21 図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Δm
Δs
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0.5
XX
IH=1.600
VIG.
-0.5
0.5